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ABSTRACT

The purposes of this booklet are to acquaint both mathematics teachers and reading teachers with some skills which students need for effectively reading the language of mathematics and to provide sample activities which may be used as an integral part of the mathematics class, in an effort to help students develop those skills. Since mathematics is an abstract science involving the use of a system with highly specialized symbolism and technical terminology, it is suggested that the mathematics teacher accept major responsibility for teaching students to read mathematics. A section on vocabulary and symbols discusses reading mathematical symbols, the directionality of such symbols, and reading mathematical words. Following directions, interpreting graphic materials, reading mathematical sentences, and reading and solving word problems are discussed in the comprehension section. Other sections include a detailed discussion of study techniques, a list of books suggested for voluntary mathematical reading, a bibliography, and a list of resource materials suggested for teachers. (MKM)

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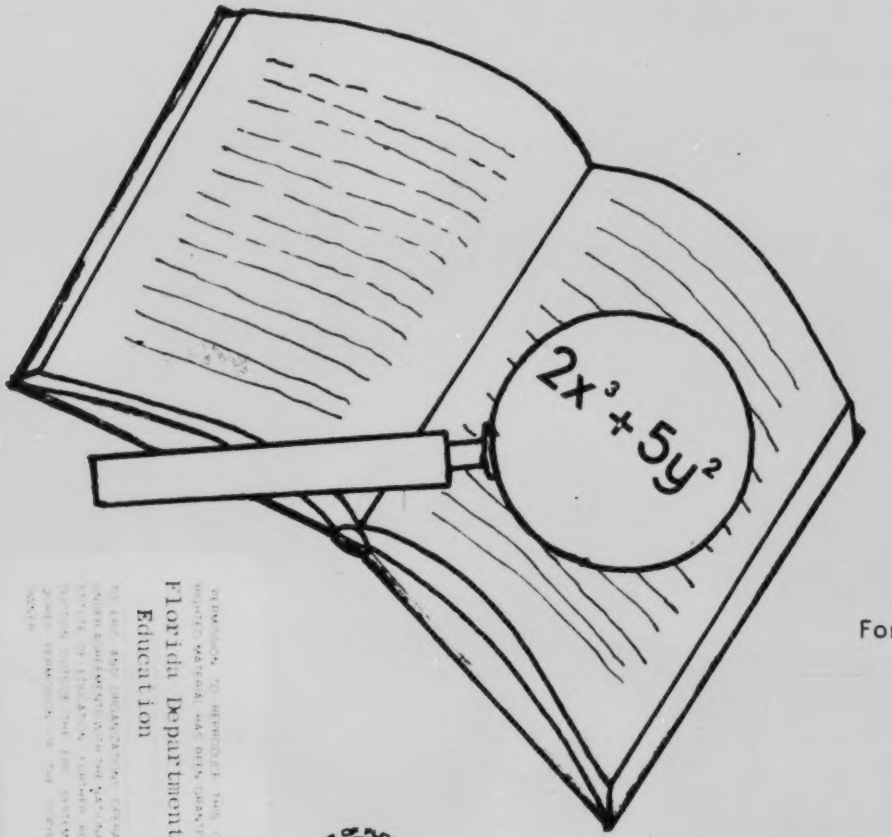
Reading the Language of Mathematics



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INTRODUCTION

Mathematics is an abstract science. It involves the use of a highly abstract symbolic system with specialized symbolism and technical terminology. Thus, the language of mathematics differs significantly from ordinary English. While many of the word attack skills learned in ordinary reading programs are applicable to the language of mathematics, more specialized skills are required to read mathematics. Effective reading of ordinary English prose does not imply equivalent effectiveness in reading mathematics.

Most mathematics educators and reading specialists agree that the development of skills in reading and communication in mathematics cannot be divorced from the development of skills and concepts in the content. No student, at any level, ever comes to a mathematics class knowing how to read all the content of the course. The reading teacher never has the opportunity to teach students to read, interpret, translate, and comprehend specialized symbols such as

$$3 + 2 = ,\ \sqrt[3]{8}\ ,\ 59^{\circ},\ \frac{3}{5} = \frac{n}{10}\ ,\ \ell_1 \perp \ell_2\ ,\ D = \begin{vmatrix} 2 & -1 \\ 3 & 1/2 \end{vmatrix}\ ,\ A = \pi r^2,\ f(x) = 3x + 1\ ,$$

$$\sum_{k=1}^{8}(1/2k-3)\ ,\ \int(3x + 5)dx,\ \tan\theta = \frac{\sin\theta}{\cos\theta}\ ,\ \text{etc.}$$

Meaningful interpretations of these mathematical symbols require considerable content knowledge on the student's part. Similarly, many seemingly familiar words take on precise technical meanings when used in mathematics (ex., solution, function, addition, square, regular, etc.). Therefore, the mathematics teacher must accept major responsibility for teaching students to read mathematics. This is not implying that mathematics teachers must teach general reading skills. This responsibility lies with the reading teachers.

As with general reading, there are no "cure-all" techniques which will allow us to easily teach all students to read the language of mathematics. Oftentimes, the battle is half won if we, as mathematics teachers, agree that a problem does in fact exist and are aware of some of the factors which make the language of mathematics difficult to read. Several factors related to the student, such as his interest and motivational level, his readiness for reading mathematics, his reading level in ordinary English, and his under-

standing of the purpose for reading mathematics contribute to the problem. However, the structure of the language of mathematics makes it difficult to read for many students. Some differences between the two languages are: (1) Ordinary English uses a standard set of 26 symbols. Mathematics uses these symbols plus many non-alphabetic, mathematical symbols. (2) The sentence structure in mathematics is different from that of English. (3) In mathematics one does not always read from left to right and down the printed page. (4) The language of mathematics is not a spoken language.

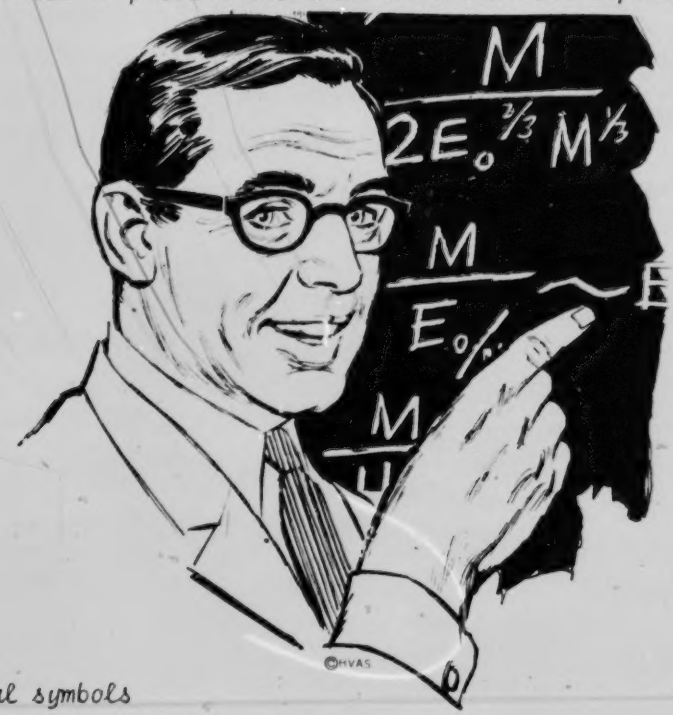
The background of experiences and ideas that a student has are important influences on how he reads and hears messages. A mathematics teacher gave this problem to a boy in a rural school: "A farmer had five cows. He killed two of them. How many cows were left?" The boy responded, "Five." The teacher repeated the problem slowly and the student again responded, "Five." The son of a farmer knows that two dead cows and three living cows are still five cows.

As teachers we need to devote much more effort to teaching students to read the language of mathematics. With improved comprehension, the student enjoys much more success in concept development, computational skills, and problem solving. When students develop the skills needed to read mathematics effectively, mathematics becomes less threatening. And much of the anxiety and frustration, for both the student and teacher, associated with learning mathematics may be eliminated.

The purposes of this booklet are (1) to acquaint both mathematics teachers and reading specialists with some skills students need to read mathematics effectively, and (2) to provide sample activities which may be used as an integral part of the mathematics class in an effort to help students develop skills in reading the language of mathematics.

I. Vocabulary and Symbols

Mathematics vocabulary and symbols are abstractions. Abstraction in itself would suggest the need for the existence of a concrete object such as an experience in sight, sound, or touch that one can abstract an idea from. Taken in a learning situation these mathematical abstractions would have more lasting meanings to students if the students were allowed to work with the concrete experiences first. Mathematics laboratory approach is a suggested method to allow experience before paperwork. Teachers need to present the ideas with concrete experiences before they present the vocabulary and symbols.



A. Reading mathematical symbols

Symbol In math, a symbol may be a character, an abbreviation, or mark which represents an idea, concept expression, quantity, or operation (+, =, { }, 5, Δ). In order to work with symbols successfully, students need to have the following competencies:

(1) They need to be able to associate a word or words with a symbol.

Example: symbol - 5 word - five

SAMPLE ACTIVITY: Have a set of cards with phrases of mathematical symbols. Have a student come to the front of the class and give the student one of these cards. Don't allow the rest of the class to see what is on the card. The student then reads out loud what is on the card in words. The other students in class write the symbols for what they hear. The rest of the students can compare their answers.

$3 + 2$	$\frac{1}{7}$	$\frac{2}{3} + 4$
$\frac{2+1}{7} + (1 \times 4)$	$\frac{(x\ y)^2}{(x+y)}$	$\log_3 x = 2$

Note: Parentheses should not have to be silent. For greater clarification, have the student actually say, "Three minus parenthesis, two plus seven," for "3 - (2 + 7)."

SAMPLE ACTIVITY: Have students rewrite or read orally mathematical expressions.

Example: 7×2 "seven times two" or "seven multiplied by two"

3×5

$4\overline{)8}$

$16 \div 2$

$4 - 3$

$5 \cdot 3$

$\sqrt{25} + 2$

$\sqrt[3]{27}$

$33/11 \times 3$

3^3

SAMPLE ACTIVITY: (For elementary age students) "The Train"

The students place their chairs in a row to make a train. One student is selected to be the "conductor." The "conductor" stands next to the student in the first seat. The teacher flashes a card with a mathematical symbol on it. The "conductor" and the "passenger" try to identify it. If the "conductor" identifies it first, he remains the conductor and moves to the side of the next passenger. If the "passenger" gets the word first, he becomes the "conductor." The challenge to the "conductor" is to see if he can go through the entire "train." The "passengers" are trying to stop him by identifying the symbols.

SAMPLE ACTIVITY: "Baseball"

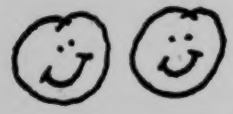
In order to play this game, the teacher divides the class into two teams and gives one team a set of flash cards with mathematical words that can be abbreviated and some with mathematical abbreviations. Four corners of the classroom may be used as bases. One student goes to homeplate. The pitcher holds up a flash card. If the card has an abbreviation on it, the batter says the word and if it has a word on it, the batter writes the abbreviation on the board. The pitcher isn't allowed to alter the order in which the cards are stacked. If correct, the batter goes to first base and the next batter comes up. Each batter advances as each teammate gets a hit. A run is scored when a student crosses homeplate. Then that team gets a point. When a team misses three, that team is retired and the other team takes over. The higher scoring team wins the game.

SAMPLE ACTIVITY: "Find your partner"

The teacher makes two sets of cards - one set with mathematical abbreviations and the other with the unabbreviated words. The class can be divided into two equal groups. One group will take the unabbreviated words and the other group will take the abbreviations. After a signal from the teacher, all the students will "scramble" to find their "partners." A person's partner is a person who has a matching card.

(2) *They need to be able to express an idea in objects, pictures, words, and symbols.*

Example: idea - "the number two" word - two objects -



SAMPLE ACTIVITY: Pictures can be drawn to interpret mathematical symbols. Along with the pictures, words can be used for a symbol. This idea can be expressed via the following exercise:

Complete:

Symbol	Word	Picture
3	three	
$\overleftrightarrow{AB}$	line	
$\frac{1}{2}$	one half	
4	four	
$\angle$	angle	

Note: In order to use this activity, the teacher would fill in only one of the columns. For variation, only one item from each column could be filled in, and have the students supply the missing information.

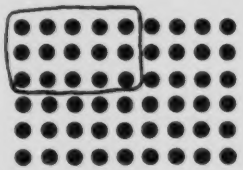
SAMPLE ACTIVITY: (For elementary age students) The teacher can make a set of cards containing statements like the following: $3 < 5$, $2 > 1$, $5 \geq 3$, $8 \neq 2$. The students can take these cards and lay some small objects such as dry beans, corn kernels, or buttons on each side of the symbols to match the numbers. This will help teach the meanings of symbols and relationships.

Example: $3 < 5$

*** *****

SAMPLE ACTIVITY: To teach the concept of commutativity, the teacher can have students put pegs into a peg board. For example, if the mathematical sentence is $3 \times 5 =$, then the student can plug in three rows of five pegs or five rows of three pegs to show the answer. To show more than one problem on a board, the student can put rubber bands of different colors around each group.

3×5



SAMPLE ACTIVITY: Have students describe the situation or object expressed by each of the following: (make this an oral activity)

(1) 72°

(2) -20°

(3) +35

(4) 0

(5) 6'

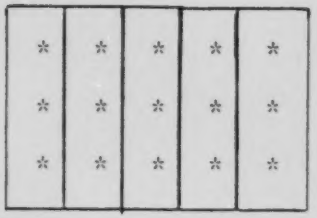
(6) 5' 3"

(7) Δ

(8) $\sin 30^{\circ}$

(9) $f(x)$

SAMPLE ACTIVITY: Have students write a division sentence and a short story to represent the drawing:



SAMPLE ACTIVITY: Grouping symbols are used for clarification in mathematical expressions. Have students tell the order in which they would perform the operations in each exercise.

Example: (1) $3(4 + 1)$ multiply, add

(2) $36 \div 3(4)$

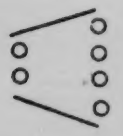
(3) $5a + 3a(b + 2b)$

Also, have students match grouping symbols:

$$(\{((5 + 4) - 2) \div (3 + 1)\} + 2)$$

SAMPLE ACTIVITY: (For elementary age students) Have students work with a pictorial development of the meanings of =, <, and >, as well as the words.

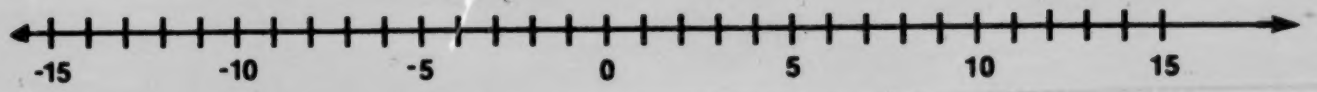
3 = 3 "*is equal to*"



2 < 4 "*is less than*"

3 > 1 "*is greater than*"

SAMPLE ACTIVITY: Use a number line to have students develop meaning to the inequality symbols. They can see 2 < 5 because '2' is to the left of '5'. They can see 3 > -4 because '3' is to the right of '-4'.



(3) *They need to be aware that there may be more than one meaning for some of the symbols.*

SAMPLE ACTIVITY: Have the students discuss the meaning of "__ " in each of the following:

(1) $\overline{AB}$

(2) 8 - 2

(3) $^{-}4$

(4) $3.\overline{3}$

B. *Directionality of reading mathematical symbols*

Directionality *In mathematics, the varied order of symbols can be read in many different directions.*

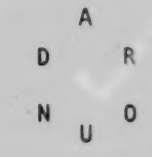
Example:

$$\begin{array}{rr} 7 & P \\ \underline{-2} & U \end{array}$$

$$\begin{array}{rr} 3 & D \\ 5 & O \\ \underline{+2} & W \\ & N \end{array}$$

DIAGONALLY

$4y^3z$



SAMPLE ACTIVITY: Make a wall chart that contains some symbols that may create a problem in reading. Guide the students through a discussion of the directions they take in reading them. With a colored pen, draw arrows to indicate the directions taken. In addition to drawing arrows, write out, in English, the expression. Discuss this chart and leave it up for further reference.

Examples:

(1) 5^2 — *"the square of five"*

(2) 5^2 — *"five squared"*

(3) $3x$ — *"three times x"*

(4) $5 : 2$ — *"five is to two"*

(5) $4\overline{)12}$ — *"twelve divided by four"*

(6) $\frac{1}{2} + 1$ — *"one-half plus one"*

(7) $6 - 2\frac{1}{3} = \square$ — *"six minus two and one third is equal to what number?"*

(8) $7 - \square = 3$ — *"what number subtracted from seven leaves three?"*

C. *Reading mathematical words*

Reading mathematical words involves:

(1) *developing word meanings by using definitions, context clues, prefixes, suffixes, and root words*

(2) *interpreting words with special meanings.*

Note: It is important that students are presented with new terms in a listening and speaking situation before they are held responsible for reading these terms. The teacher should use

every opportunity to associate the spoken word with the written word (pointing to the words written on the blackboard, charts, etc.) when they are verbalized by the teacher.

(1) Developing word meanings

a. Using definitions (both in the text and in the dictionary)

The meanings of words in the language of math are usually more precise than in some other disciplines. The definitions are clearly delineated and there are no shades of meaning for them. When students are learning a word in mathematics, they have to do more than memorize and vocalize. They have to develop ideas and concepts represented by that word, in order to grasp the meaning of the material.

SAMPLE ACTIVITY: Have students make true statements by combining the words on the left with some of the phrases on the right. Students should draw arrows from each word to the phrase which makes the statement true.

(1) An arc is	(a) a figure having six equal sides.
	(b) part of a circle.
	(c) the perimeter of a circle.
(2) An angle is	(a) the union of two rays having a common endpoint.
	(b) a five-sided polygon.
	(c) a point at or near the center.
(3) A right angle is	(a) an angle having 90°.
	(b) looks like a rectangle.
	(c) has 180°.

(4) A square has	(a) four equal sides. (b) six equal sides. (c) five equal sides.
(5) Intersecting lines	(a) cross at <u>one</u> point. (b) are parallel. (c) never touch.
(6) Perpendicular lines	(a) are parallel. (b) form right angles. (c) never touch.

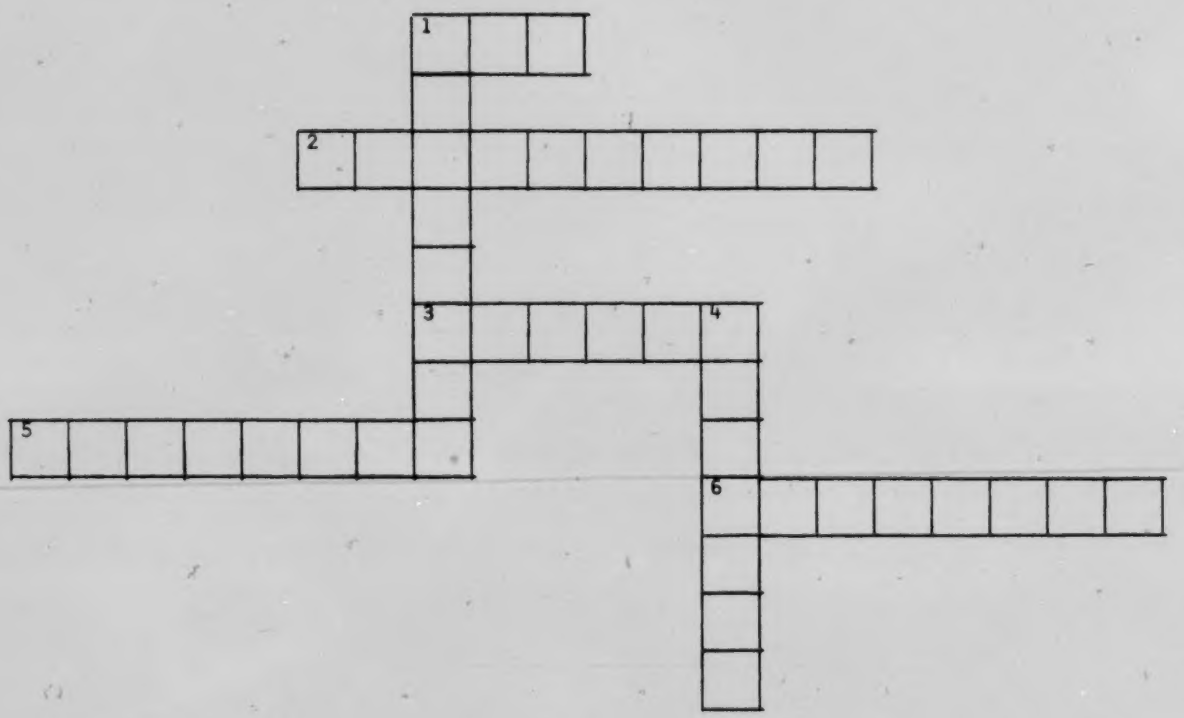
SAMPLE ACTIVITY: The following is a list of definitions taken from your reading. See if you can solve the puzzle by filling in the correct words.

ACROSS

1. The result one gets when one adds.
2. The number one takes from another number.
3. A number to be added to another number or to itself.
5. The result one gets when one divides.
6. $\{\ldots, {}^{-}3, {}^{-}2, {}^{-}1, 0, {}^{+}1, {}^{+}2, {}^{+}3, \ldots\}$

DOWN

1. To take away.
4. $6\overline{)12}$ The number six in this problem.



SAMPLE ACTIVITY: Give some definitions, real or contrived, and have students use them to answer pertinent questions about main points in the definition.

Trapezoid: A quadrilateral that has only one pair of opposite sides parallel.

a) How many sides does it have? How do you know?
b) Can any quadrilateral be a trapezoid? Why or why not?
c) Does this definition differ from the one in your textbook? How?

SAMPLE ACTIVITY: Give the students some words with different meanings and see if any of the non-mathematical definitions relate in some way to the mathematical ones. Have the students express their viewpoints on these relations of meaning and explain their particular opinions.

SAMPLE ACTIVITY: Allow the students to make up their own definitions, either silly or serious, for new mathematical words.

common denominator: unexciting number

parallelogram: the unit of weight for parallel lines

SAMPLE ACTIVITY: The students can create their own mathematics dictionary. Words and definitions can be put on cards and later transferred to a booklet. Keeping them on cards at first will allow the students to be able to put them in alphabetical order after the collection is completed. The students can put in their own illustrations.

SAMPLE ACTIVITY: Once the terms have been defined and discussed by the class, the students can define the terms in their own words.

b. *Using context clues*

Ability to use context is a necessary skill for students to have if they are to read mathematics with meaning. During the process of reading, students get clues from pictures, diagrams, examples, and sometimes familiar words in the sentence or the paragraph. The following activities indicate ways in which students can be helped in searching for context clues.

SAMPLE ACTIVITY: The teacher should make exercises like the following where every tenth word or symbol is deleted and give to the students for their responses. The students should fill in the blanks with correct words or symbols (synonyms should be allowed).

If two fractions have like numbers for their denominators, ____ fraction with the greater numerator is the greater fraction. ____ is greater than $1/3$. However, to compare two fractions ____ unlike denominators, we must first express the two given ____ as fractions with a common denominator and then we ____ consider the given fraction that is equivalent to the ____ having the greater numerator and common denominator as the ____ fraction.

SAMPLE ACTIVITY: Tell the meaning of the underlined words. Use the words around them to help you with their meanings.

(1) $10 \div 5 = 2$. We call the numeral five a <u>divisor</u>.

(2) $30 - 10 = 20$. We call the numeral ten a <u>subtrahend</u>.

(3) Fractions like $^1/_2$, $^2/_3$, $^3/_5$, and $^4/_5$ are called proper fractions. Fractions like $^3/_2$, $^4/_3$, $^7/_3$, and $^5/_4$ are called <u>improper</u> fractions.

c. *Using prefixes, suffixes, and root words*

Knowing the meanings of prefixes, suffixes, and root words can be helpful in getting the meaning of certain mathematical words. For example, the words add, adding, addend, additive, adds, *and* addition *share a common root. The students have probably learned many of these; therefore, they can be guided into adapting them to math.*

SAMPLE ACTIVITY: Have students name as many words as they can that begin with the following:

tri	poly
mid	sub
in	sum
ex	un
bi	circum

then have them identify the ones that are mathematical.

SAMPLE ACTIVITY: Match each word on the left with the meaning of a prefix on the right which could help with identifying the meaning of the word.

(1) quadrilateral	_____ (a) five
(2) exterior	_____ (b) around
(3) semicircle	_____ (c) eight
(4) pentagon	_____ (d) two
(5) circumference	_____ (e) four
(6) octagon	_____ (f) equal
(7) triangle	_____ (g) half
(8) bisect	_____ (h) three
(9) equilateral	_____ (i) outside

SAMPLE ACTIVITY: The teacher can use flash cards on which have been printed mathematical roots and prefixes. Have the students name as many mathematical words as they can that contain these prefixes and roots. Some examples could include the following: *add, multi, sub num, equa, equi, circum, didi,* etc.

SAMPLE ACTIVITY: The teacher prepares cardboard strips by cutting 3" x 8" pieces of cardboard. Print mathematical words that contain identifiable prefixes on one side of the cards. Cut each card so each word will be divided between the prefix and the root word or suffix. Mix the cards and have students make words by matching the cards. If the teacher would write possible combinations on the back of the cards, the students can check their answers.

(2) *Interpreting words with special meanings.*

A number of words take on highly specialized meanings in mathematics: solution, plane volume, power, root, group. Some of these words have multiple meanings, even within the language of math: degree, square, base.

SAMPLE ACTIVITY: Write a sentence using each of these words in a mathematical way:

(1) angle
(2) degree
(3) plane
(4) odd
(5) base
(6) square
(7) set
(8) volume
(9) solution
(10) power

SAMPLE ACTIVITY: Help the student read a certain chapter in a math book and look for specific words and their meanings. Then match each word with a meaning to show how it was used in that chapter.

WORDS	POSSIBLE MEANINGS
(1) square	(a) super conservative person
	(b) the product of a number multiplied by itself
	(c) an unopened cotton flower
	(d) a rectangle with sides of equal length
(2) degree	(a) the largest power of a variable in a polynomial
	(b) unit of measure for temperature

(c) unit of an angular measurement

(d) a step in a process

(3) range

(a) a cooking stove

(b) grassland used for livestock grazing

(c) distance a bullet travels

(d) the set of second elements in a set of ordered pairs

(e) difference between the lowest and highest scores in a group of scores

(4) base

(a) foundation

(b) main ingredient

(c) military installation

(d) that which is taken to a power

II. Comprehension

Comprehension is the act of getting meaning from a printed or spoken language; a cover term for all the skills and abilities involved in getting meaning from a printed or spoken language. It includes, in addition to other skills and abilities, the skills and abilities classified under literal and interpretive comprehension. Literal comprehension is the understanding of the direct meaning of a word, phrase, sentence, or longer selection. For example, noting important details is a literal comprehension skill. Interpretive comprehension is the understanding of the implied meaning. For example, locating the main idea or major details when they are not directly stated by the author would be an instance of interpretive comprehension. Sometimes in a mathematics problem, an operation is implied rather than directly stated. Students must be able to key in to this implied information so they can recall or locate information to help them understand a new algorithm or concept.

In order to comprehend mathematics, students need to possess the following competences: (A) They need to be able to understand main ideas and important details. (B) They need to be able to follow directions. (C) They need to be able to interpret graphic materials. (D) They need to be able to read mathematical sentences.

A. Understanding main ideas and important details

It is important for students to be able to identify and understand main ideas and supporting details. They must also be able to see the relationships between main ideas and supporting details. The main idea may appear at the beginning, in the middle, or at the end of a page. It may be found by looking at diagrams, tables, examples, pictures, etc. In some problems, it may be in italics, in boldface type, or underlined.

SAMPLE ACTIVITY: Students can turn to a page in the math book and answer specific questions asked by the teacher or the teacher can write a passage and questions, like the following, about it.

(1) What is the main idea?

(2) Name several supporting details.

(3) How are the main idea and details related?

SAMPLE ACTIVITY: (For secondary age students) Trigonometric identity.

Students can answer these questions as they read the passage for meaning.

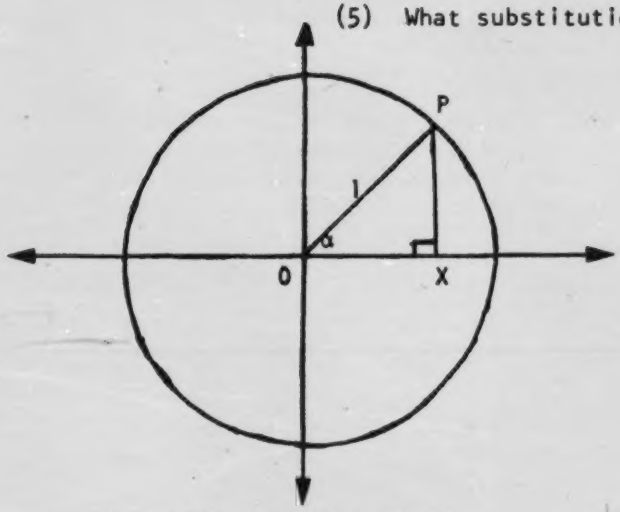
(1) Put a check where you first knew how to find the trigonometric identity.

(2) How did you find this identity?

(3) What previously learned ideas did you have to recall?

(4) Where did you discover you were going to use trigonometry?

(5) What substitutions in the formula did you have to do?



This is a diagram of a circle of radius "1". Now look at the right triangle $\Delta 0XP$. State the formula for finding the length of the hypotenuse _____.
Now use $d\overline{PX} = \sin \alpha$ and $d\overline{0X} = \cos \alpha$ to find the trigonometric identity:
1 = _____.

B. *Following directions*

This skill requires that the students read and perform the activities they are instructed to do. Directions in mathematics often cannot stand alone. For example, "simplify" can mean to combine like terms or to reduce a fraction. Since students often skip directions, teachers should be able to clarify directions and "walk" students through them. Often when working with

a complex mathematical problem, a rule of thumb is that third graders grasp one-step directions, fifth graders grasp two-step directions, and eighth graders grasp three-step directions.

SAMPLE ACTIVITY: In addition to "walking students through a direction," a teacher can help the students learn to follow directions by having them rewrite step-by-step directions in their own words.

SAMPLE ACTIVITY: (For elementary age students) Oftentimes young students need to be reminded to carefully read and follow directions. In order to keep them aware of this, the teacher can from time to time give the students a list of simple directions to follow. The following directions may be used:

(1) Open your mathematics book to page five.

(2) Write, on your paper, the first word that is printed at the top of page five.

(3) Read the first problem on page five.

(4) Write the answer to the first problem.

(5) Close your book.

(6) Draw two triangles on your paper.

(7) Color one triangle blue.

(8) Pass your papers up.

Note: An activity like the one above should be increased in complexity as the students become more sophisticated.

SAMPLE ACTIVITY: Have the students follow the directions to add these numbers written with decimals: 1.701 + 20.03 Use this to add: 2.022 + 1.4; 13.002 + 7.0. First, rewrite them so that the decimals are lined up as shown:

1.701 + 20.03	This allows those digits to be added that have the same place value. The 20.03 can be rewritten with a "0" in the thousandth's place because there are no thousandths there.
1.701 + 20.030	Then add like digits and remember to put the decimal units in proper place in the answer, keeping it lined up with the others.

Now do the other two addition exercises.

C. *Interpreting graphic materials*

Graphic materials are important in mathematics. They compact many mathematical ideas in a relatively small amount of space. Students should begin developing skills in reading graphs at a simple level and progress gradually to more complex situations.

SAMPLE ACTIVITY: Have students make their own graphs. Small groups can graph different characteristics of the class. The following characteristics could be used:

(1) Students' heights

(2) Students' weights

(3) Color of eyes

(4) Types of books liked

(5) Types of movies liked

(6) Favorite school subjects

SAMPLE ACTIVITY: Give the students a graph and ask specific questions about it:

Underline the statements which are true:

(1) Dennis made more points than Elijah.

(2) Kyle made fewer points than Carlos.

(3) Three of the players made fourteen points each.

(4) Betsy made fewer points than Bernard.

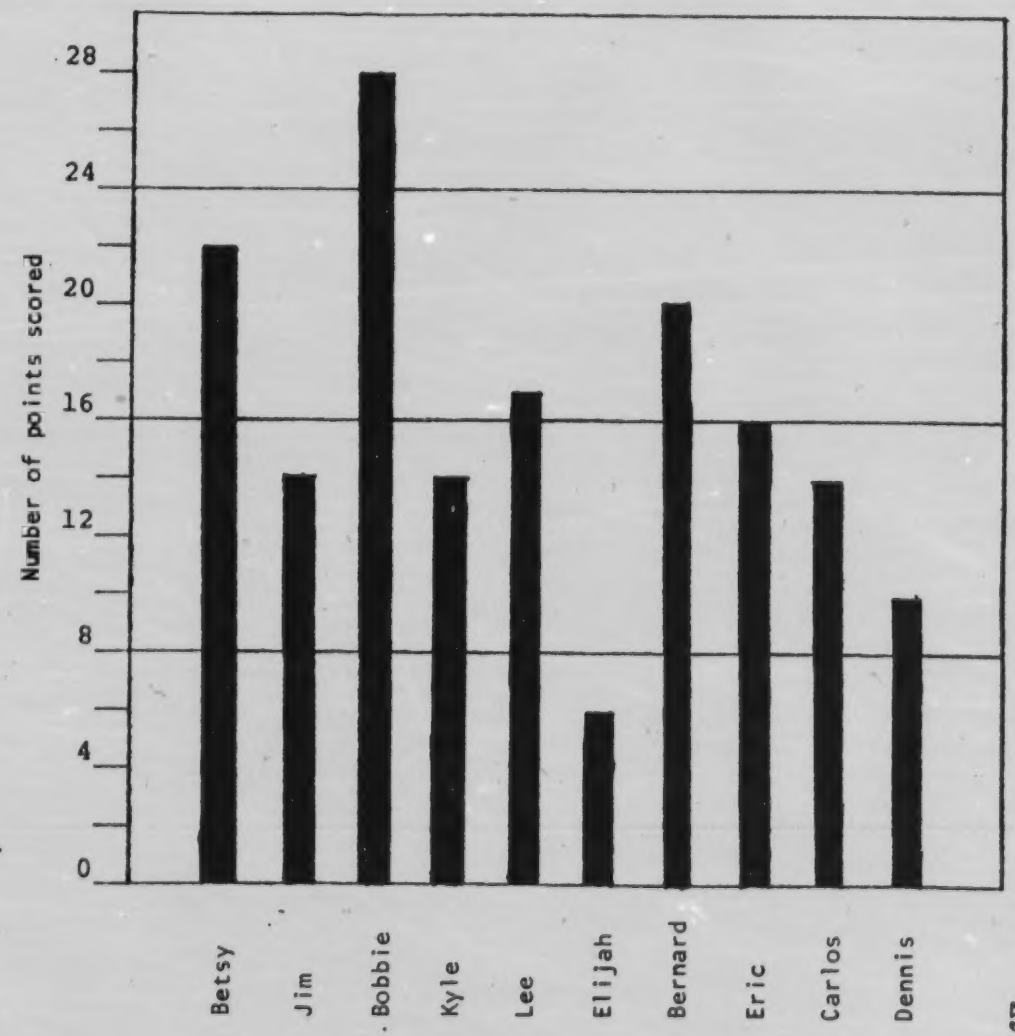
(5) Bobbie made more points than anyone.

(6) There are 12 players shown on the graph.

(7) Lee made 17 points.

(8) It is possible to show $7^1/_2$ points on the graph.

BASKETBALL TEAM



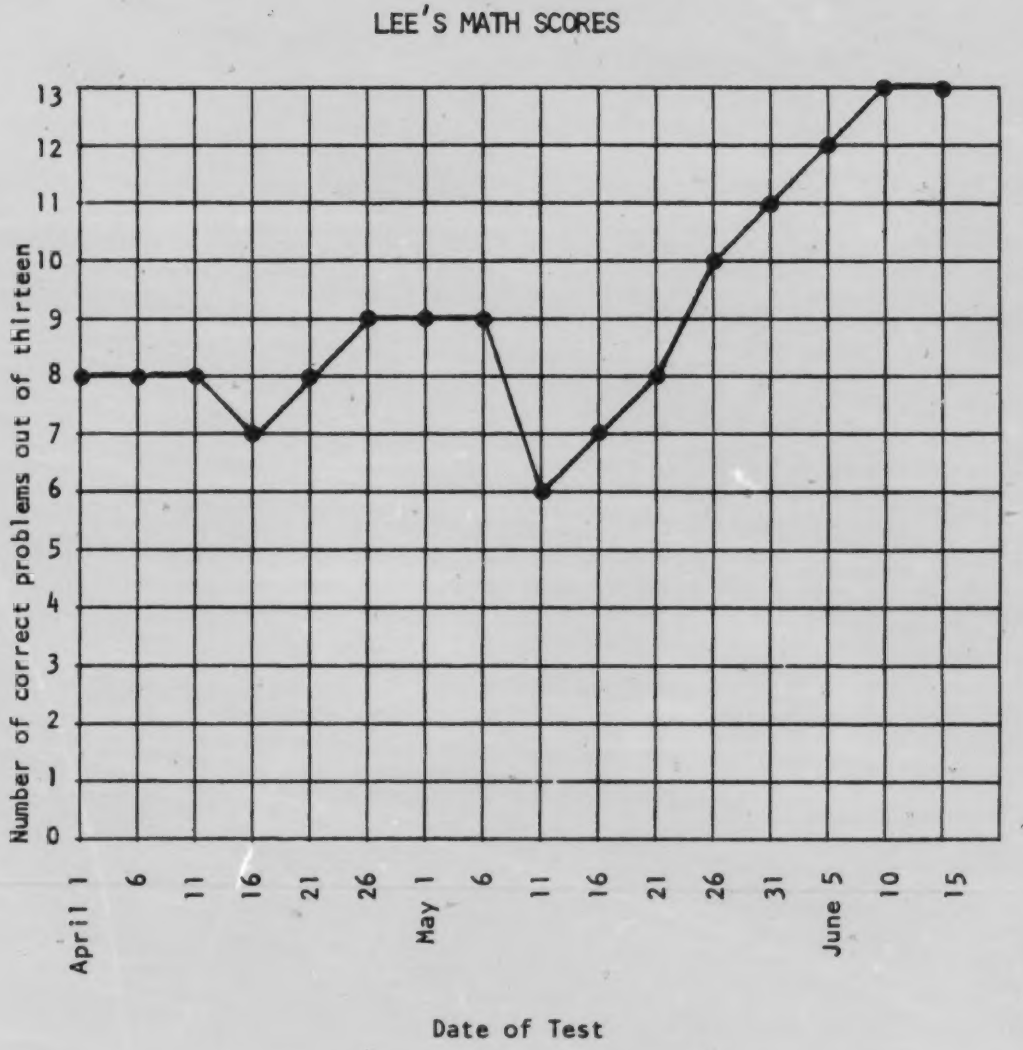
SAMPLE ACTIVITY:

(1) What is the purpose of this graph?

(2) On what date did Lee get the least number of problems correct?

(3) On what date did Lee get twelve problems correct?

(4) On what date did Lee's score double a previous score?



SAMPLE ACTIVITY:

Set A = {1, 2, cat, 5}

Set B = {3, 4, dog}

Set C = {1, 2, cat, 7, 8}

Set D = {4, dog}

(1) Trace the curve around Set A.

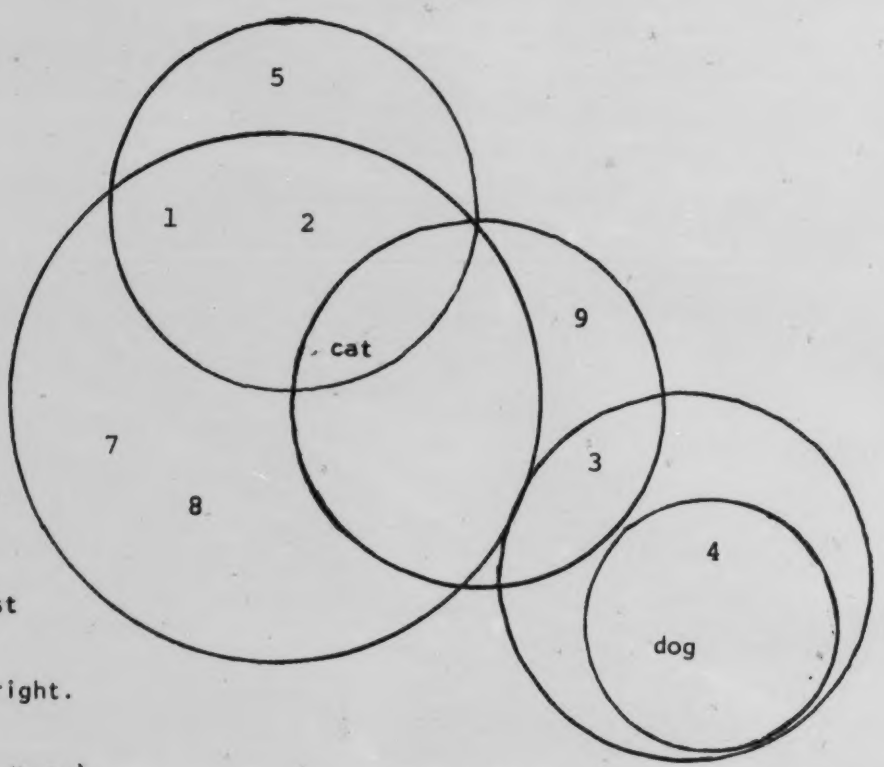
(2) Trace the curve around Set C.

(3) Does Set B contain any of Set A?

(4) What set is totally encircled by another set?

(5) Set E is drawn but not listed. List its elements.

The Venn diagrams of these sets are at right.

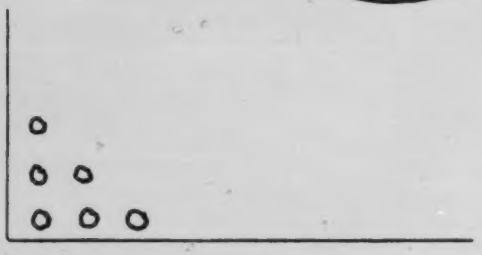


SAMPLE ACTIVITY: (For secondary age students) Some graphs use a symbol that represents a larger number. Pick your own axis for whatever labeling you want, but you must pick an axis for the names *John*, *Pat*, and *Henry*, in that order, either left to right or top to bottom.

(1) Who has the most snowballs if names are labeled on the vertical?

(2) Who has the most snowballs if names are labeled on the horizontal?

(3) Who has three snowballs if names are labeled on the vertical?



Key: O = 3 snowballs

D. Reading mathematical sentences

Reading mathematical sentences involves at least two reading skills. It involves (1) recognition and pronunciation of words and symbols and (2) attaching meaning to the complete sentence. The following is a model of a math sentence. Following it are examples of math sentences.

symbol that names a thing — symbol that names a thing

symbol that names a relationship

$1 + 3$	$=$	$2 + 2$
$9 + y$	$\leq$	$5y + 2$
$A \quad B$	$\leq$	C
ΔABC	$\equiv$	ΔBCD
ℓ	$\parallel$	m

SAMPLE ACTIVITY: Have the students answer specific questions concerning mathematical sentences.

$6 + 7 = 13$

(1) What is the operation?

(2) What does the "1" tell you in the above sentence? The "3"?

(3) How much *more* than 6 is 13?

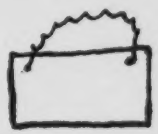
(4) Write the sentence using words. Is it a true sentence?

(5) Write the sentence in words, reading from right to left. Does it still sound true?

Note: When we write "1 + 3 = ☐ and do not explain it, we sometimes give the idea that this is the only order in which this sentence can be written. Many times when students see "4 = 1 + 3" they are confused about the order in which it should be read. This causes them to think that this is an incorrect form.

SAMPLE ACTIVITY: Create the reverse and turn "4 = 1 + 3" into a more common form. Write an addition combination in the blank that names 4. 4 = ☐. The students could be asked to set up several renamings for various numbers and operations. For example: 5 = ☐ (35 - (3 + 2)) ÷ 6) .

SAMPLE ACTIVITY: (For elementary students) "Living Number Sentences" Have cards (8" X 11") with strings attached so students could wear them. On each card write one of the following symbols (if appropriate for your class): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -, =, <, >. Make several cards with each symbol. The students can be called on, one at a time, to choose a card to wear. They can stand facing the class to build a living number sentence. If students do not choose cards that match, they have to wait for a chance to fit in the sentence.



E. *Reading and solving word problems*

Many students experience difficulty when they are asked to solve word problems. They are able to solve the problems without difficulty when someone aids them by performing the translation for them. In order to experience success with solving word problems, students need to have the following competencies: (1) They need to be prepared for reading word problems. (2) They need to be able to analyze the information in word problems. (3) They need to be able to translate and use signal words. (4) They need to be able to identify sufficient, insufficient, and extraneous information in a word problem. (5) They need to be able to employ some strategy, someone else's or their own, that will help them solve word problems.

1. *Preparing for reading word problems*

In reading, the word readiness is used to refer to a student's preparedness to successfully understand beginning reading instruction or a reading activity at any level of instruction. Readiness for reading must be present in all reading activities from kindergarten through adult education needs. Likewise, in mathematics, readiness to perform a given task is needed. If students cannot adequately read and understand a word problem, they must be given help to do so. The help can be given by the teacher or another student. A mathematics teacher cannot afford to ignore the reading levels of the students, nor of the material to be read. Every attempt should be made to facilitate the learning process.

Another consideration of readiness is to be sure the students can perform the necessary arithmetic and algebraic operations required to solve the problem. Even if they have analyzed the problem, they cannot solve it unless they can perform the required arithmetic and algebraic operations.

Word problems should be assigned in small doses. Teachers should keep this in mind when making assignments. Teachers should also consider arranging problems according to difficulty. This should help the students succeed.

SAMPLE ACTIVITY: Let students get in small groups, make up problems of their own and state them in their own words.

2. *Analyzing*

Students need to be able to state meanings, relationships and needed operations in order to solve a word problem. They have to be able to state the problem situation correctly in their own words and determine what is being asked. They should be able to follow ideas in a sequential manner.

In an effort to build skills in analyzing word problems, the teacher can use an activity like the following in which the students are required to respond to a list of questions about a problem situation.

SAMPLE ACTIVITY: Have students read some verbal problems and supply the information asked for in the following chart:

	What information is needed?	What terms need defining?	What operation is needed?	What is the order of operations?	What variables are given?
Problem 1					
Problem 2					
Problem 3					
Problem 4					

SAMPLE ACTIVITY: Give students word problems and have them ask as many questions as they can about the problems. Have students use the previous activity as a model in making their own activity.

SAMPLE ACTIVITY: Have students read verbal problems and list the operations they must employ to solve the problems.

SAMPLE ACTIVITY: The student needs to decide on the order of operations.

	First	*Second*
(1) Average of his grades	add	divide
(2) 7% gain	multiply	add
(3) 5% decrease	multiply	subtract
(4) 4 more than 5 times a number	multiply	add

If a student finds it hard to organize his thoughts, it is the responsibility of the teacher to determine if the material is too hard or if the student needs help with organization.

SAMPLE ACTIVITY: The teacher can select a word problem that requires the students to think in sequence. Each sentence should be written on a separate cardboard strip and put in an envelope. The student can then open the envelope, take out the strips and arrange them in order. If the teacher would put the numbers on the back of the strips, the student can check his own work. These strips can be made to use with a flannel board or they can be pinned on a cork board. If all students in a class are having problems in this area, the teacher can give each one an envelope and when he finishes, he can swap his envelope with someone else.

Suggested problem. Carmen worked as a cashier in a department store one summer. One week, she worked long hours. On Monday, Tuesday, and Wednesday, she worked 9 hours per day. On Thursday, she worked 8 hours. On the other two days she worked 5 hours each. At $2.25 per hour, how much money did she earn that week?

SAMPLE ACTIVITY: Have students circle the following items that could be combined for each operation. Stress that only numbers with common units may be added together.

(1) addition:	7 hours	2 days	4 gallons	8 hours
(2) subtraction:	8 days per year	9 weeks per year	2 days per year	3 days
(3) division:	9 miles	2 miles	3 hours	4
(4) division:	9 miles	2 miles	3 miles per hour	5 hours

Note: Answers may vary on (3) and (4).

9 miles ÷ 3 hours = 3 miles per hour

9 miles ÷ 3 miles per hour = 3 hours

SAMPLE ACTIVITY: Have students analyze the following problem situation by answering the questions related to it:

A missile traveling 9000 miles per hour is shot at a fighter plane 100 miles away. If the plane is going away from the missile at 300 miles per hour, how far will the plane fly before the missile overtakes it?

a) If x = distance plane flies, represent the distance the missile travels.

b) What is the relationship between the time the plane flies and the time the missile travels?

c) Distance = rate X time. Express the time the plane flies using this formula.

d) Express the time the missile travels.

e) Using the information from (b), (c), and (d) above, write an equation which will allow you to solve for x.[1]

3. *Translating and using signal words*

In order to solve a word problem, students must be able to take the printed words and translate them into mathematical sentences. Certain words and phrases can serve as clues to mathematical operations that solve the problem.

SAMPLE ACTIVITY: List the symbol and the word for each operation.

	Symbol for Operation	Word for Operation
(1) less 7	-	subtract
(2) the difference		
(3) a number increased by 8		
(4) seven percent of sixty		

[1] Phillips, E.R., and Uprichard, A.E. The correlation of selected mathematical measure with problem solving ability. Florida Journal of Educational Research, 1974, 16, 3-11.

	Symbol for Operation	Word for Operation
(5) twice the amount		
(6) sum of their ages		
(7) decreased by		
(8) 80' board cut in half		
(9) seven hours are more than Fred worked		
(10) how many dollars per day?		

SAMPLE ACTIVITY: Let students write their own word problems that will use the idea of different operations. For example word problems can be written that deal with addition, multiplication, division, and subtraction.

SAMPLE ACTIVITY: Have students take some verbal sentences and translate them into mathematical sentences. This activity shows how the translation from English into the language of mathematics involves ordering.

Words	1st Translation	Math
(1) John is two years older than Mary.	John's age is Mary's age plus two.	J = M + 2
(2) For two hours, he went many miles at a particular speed.	number of miles is found by multiplying his speed by two	M = 2 x S

SAMPLE ACTIVITY: After students have studied certain formulas for solving problems, give them reading problems to translate.

1. The problem: The man drove to Gainesville, a distance of 150 miles, in 3 hours. What was his rate in miles per hour?

   Formula Substitution Answer

2. The problem: The students in a home economics class want to cover two round tables with contact paper. Each table has a radius of three feet. How many square feet of contact paper will they need to cover the two tables?

   Formula Substitution Answer

SAMPLE ACTIVITY: Before a student uses math skills to perform the operations in some word problems, he is required to translate the phrases in those problems. Translate the following verbal instructions into mathematical language. Use a different variable in each part.

1. A number is tripled, and the result decreased by one; this last number is increased by five, and that result is divided by two.

2. A number is doubled and the result is increased by eleven.

3. A number is increased by twice another number; the result of that is decreased by three and then divided by four.

4. *Identifying sufficient, insufficient, and extraneous information.*

Many times in a math problem, one will find that there is not enough information to solve the problem or sometimes there will be enough plus some extra which is not needed to solve the problem.

SAMPLE ACTIVITY: Give some word problems and ask students whether there is enough information to answer the questions.

SAMPLE ACTIVITY: Have students indicate, by crossing out, underlining, or circling, the extraneous information in word problems.

5. *Using general strategies to solve word problems*

In order to enhance a student's problem solving skills, teachers may need to help students develop some systematic approach for attacking word problems. The first activity that follows suggests only one approach. The second activity helps the students develop their own approaches.

SAMPLE ACTIVITY: Using a word problem, "walk" students through the following strategy:

(1) Scan the material for the purpose of locating specific information.

(2) Reread for important facts.

(3) Interpret clue words.

(4) Decide on an order if more than one operation is used.

(5) Check to see if there is enough information.

(6) Get a trial answer.

(7) Ask if solution is reasonable.

(8) Check your answer. If it is wrong, start the process over.

SAMPLE ACTIVITY: Give students various types of word problems to solve and have them explain their own steps to getting an answer.

III. *Study techniques*

Study techniques are those techniques used to locate and understand specific information in factual materials. These techniques require the gathering, organizing, and understanding of materials read. It is important for students to develop good study techniques. When students consistently use these techniques, they become independent learners. In order for students to be

competent in this area, they need to develop the ability to (A) adjust their reading rate to the material, (B) read with paper and pencil, (C) make use of book parts, (D) utilize pages and book format, (E) use a mathematics dictionary, and (F) use a study formula.

A. *Flexible reading rate*

The student must learn to adjust his reading rate in relation to the type of material read. When the student moves from narrative material to more concise mathematical ideas, he is required to adjust his rate of reading to the material. On occasion, material requires the ability to scan; sometimes it requires the ability to skim; but generally mathematics material should be read in a very careful and precise manner.

SAMPLE ACTIVITY: When the students have read a passage, involve them in a contest to find all the mathematics words they can find in a certain time limit. Then give them a time limit to find additional information. Finally, have them close their books and see how much they remember. As the students orally recall information, the teacher writes this information on the board. Now, have the students go back to their books and check to see how much information was not remembered from the skimming activity.

SAMPLE ACTIVITY: Assign a page in a mathematics book to be scanned by the students. After they scan it, have them summarize what they have learned. Next, have them read that same material carefully and summarize it. When this is finished, have them compare what they comprehended when they scanned to what they comprehended when they read carefully.

Since symbols hold such a quantity of information, students should be helped to see that it takes longer to read and understand them than it takes to read and understand non-symbolic terms.

SAMPLE ACTIVITY: Assign a page of narrative material and also a page of mathematical material. Have students compare reading time and content extracted.

B. *Reading with paper and pencil*

This is not to be confused with the kind of note taking done in a history or some other class. This is the type of writing that allows the readers to complete number sentences, to perform indicated computations, to write questions and answers, and to draw diagrams that will aid their thinking processes while they are reading. Using paper and pencil aids in the internalization, comprehension, and recall of information.

SAMPLE ACTIVITY: Use paper and pencil when reading in order to fill in the missing material:

$3 \times \square = 6 = 2 \times \triangledown$

$\triangle \times 5 = 15 = 3 \times \square$

Show $2 \times \square = 8$ on Grid A

Show $\square \times 2 = 8$ on Grid B

Grid A

* * * * *
* * * * *
* * * * *
* * * * *
* * * * *

Grid B

* * * * *
* * * * *
* * * * *
* * * * *
* * * * *

Make up two multiplication expressions for the number 12 that use the same factors. What can you say about multiplication and the order of numbers?

C. *Using book parts*

A student can appreciate his mathematics textbook more if he learns what information is in it and how valuable it can be to him.

SAMPLE ACTIVITY: "Scavenger Hunt"

The teacher could make a list of locational type questions and conduct a class session where students look for information. The class can be divided into two teams. One question is asked at a time and the students look for the answer. When an answer is found by a team, it is shown to the entire class and that team receives a point.

Suggestion questions:

(1) On what pages did you find information about absolute value?

(2) How many pages are in chapter two?

(3) What is the title of chapter twelve?

(4) How many subtitles are in chapter one?

(5) Who is the author of the book?

(6) What is the copyright date of your book?

(7) What is the fifth word in the glossary?

(8) What information can you find about the cover?

(9) On what page is the chapter summary for chapter three?

(10) Give the name of the publisher.

(11) Where is the preface located?

(12) Locate the tables in your book and give the uses of each.

(13) Are answers to all problems given on the answer pages?

(14) How many pages of answers are there?

D. Utilizing the format

1. Page format

To use the page format effectively, a student needs to pay attention to the method by which information is presented on a page: boldface type, italics, in boxes, color coded, or pointed out by using a star, an arrow, or an asterisk.

SAMPLE ACTIVITY: If students find a mathematical word they do not know, have them check the page to see if the definition is given. If it is not, then have them check the preceding pages and the glossary. Have the students complete the table using their textbooks:

Word	Page on which definition was found	Method used for Presentation of definition

2. Chapter format

Chapter format is the organization of a chapter. A chapter is arranged with titles, subtitles, references, and diagrams. Knowledge of this organization can aid students in locating information.

SAMPLE ACTIVITY: Before beginning the work in a chapter, the teacher can guide the students through an activity where questions like the following are asked:

1. What is the title of this chapter?
2. What are some of the subtitles?
3. Read some of the information that is highlighted in some way.
4. What are the different ways in which the information is highlighted?
5. How long is the chapter?
6. Are there references made to other materials?
7. What equipment, such as rulers, compasses, strings, protractors, and straight edges, is needed?
8. On what pages did you find information about using the above equipment?
9. Are there pictures, diagrams, and charts in this chapter?
10. What kinds of information do pictures, charts, and diagrams provide?
11. Based upon your survey of this chapter, what do you think we are going to learn?

SAMPLE ACTIVITY: Have students find examples in the chapter that will help them work certain related exercises, either at the end of the chapter or given by the teacher.

SAMPLE ACTIVITY: Give exercises to be worked and give varied examples, some of which are to be picked by the students as being best at helping them to work the exercises.

E. *Using a mathematics dictionary*

A mathematics dictionary can be invaluable to the teacher, as well as a useful resource for the students.

SAMPLE ACTIVITY: Duplicate, on acetate, pages from a mathematics dictionary and project them on a screen for the purpose of showing the students how to use the dictionary. The following guidelines can be used:

(1) Show that the listings in a mathematics dictionary, like any other dictionary, are in alphabetical order.

(2) Show one page that contains illustrations.

(3) Show a few of the terms listed.

(4) Show, by underlining, the key words and phrases in some of the definitions.

(5) Show the kind of information found in the appendix:

a. Table of Common Logarithms

b. Table to Trigonometric Functions

c. Table of Compound Interest

d. American Experience Table of Mortality

e. Table of Squares, Cubes, Square Roots, and Cube Roots of Integers

f. Denominate Numbers

g. Differentiation Formulas

h. Greek Alphabet

i. Trigonometry and Hyperbolic Functions

F. *Using a study formula*

SQ3R is a systematic method of studying textbook material. It consists of these steps:

Survey: Skim through the material to get an idea of its content and organization.

Question: Form questions about the material.

Read: Read the material; keep in mind the answers to the questions as they are found.

Recite (Rewrite): Recite (rewrite) the important points of the material and the answers to the questions.

Review: Review the answers to the questions and other information learned from the material.

SAMPLE ACTIVITY:

(1) Survey: Locate the assigned reading. Locate the exercises to be worked for the assigned material. Look at pictures, maps, charts, and graphs; find the main topics of the material and formulate questions about them. Skim for important vocabulary, and look at all highlighted and boxed material.

(2) Question: Turn the main topics and headings into questions; find those questions that the material asks.

(3) Read: Make an active search to answer these questions.

(4) Recite (Rewrite): Try to put the main ideas of the questions for which you found answers in your own words.

(5) Review: Try to recall main points and subpoints.

G. Voluntary mathematical reading

Teachers need to be aware of mathematics related trade books on the students' level. These books could be used as motivation. One way to use them is to keep a "book table" where students can go read when they complete their other work.

SAMPLE ACTIVITY: Have a banquet for mathematicians.

Procedure: Supply the students with names of mathematicians and a list of materials for locating information about these mathematicians. Allow time for research. Encourage each student to dress up in a costume and imitate the person he studied. During one or two class periods, the banquet can be held. At the banquet, each "mathematician" will introduce himself and talk very briefly about one of his accomplishments. The teacher could act as master of ceremonies.

SAMPLE ACTIVITY: As a follow-up activity to a mathematics unit in an elementary class, have the students read mathematics related books. Titles of some of these books may be found in the bibliography of this booklet.

Suggested Books for Voluntary Mathematics Reading

For students (annotated):

Adler, Irving. The Giant Golden Book of Mathematics. New York: The Golden Press, 1960.
Picture book of the beauties of mathematics.

Barnard, Douglas St. Paul. It's All Done By Numbers. New York: Hawthorne Books, Inc., 1968.
Points out the fun to be had with numbers.

Hunt, Leslie L. 25 Kites that Fly. New York: Dover Publications, Inc., 1971.
Patterns and instructions for making kites.

Juster, Norton. The Dot and the Line. New York: Random House, 1963.
A love story for lovers of geometry.

Leaf, Nunro. Arithmetic Can Be Fun. Philadelphia: Lippincott, J.R. Co., 1949.
Cartoons, very simple beginning arithmetic, yet fun.

Luce, Marnie. Zero is Something. Minneapolis: Lerner Publications Co., 1969.
Demonstrates with words and pictures all the uses of zero.

Ruchilis, Hy. The Story of Mathematics. Irvington-on-the-Hudson, New York: Harvey House, 1958.
Pictures demonstrating that math is in everything.

Russell, Solveig. Lines and Shapes. New York: Walch, Henry Z., 1965.
Mathematics of everyday things.

Westcott, Alvin M. and Schlvep, John. Fun with Timothy Triangle. Mankato, Minnesota: Oddo Publishing, Inc., 1967.
Light, fun, informative.

Willerding, Margaret F. From Fingers to Computers. Pasadena, California: Franklin Publications, Inc., 1968.
Colorful pictures and story of the development of computers.

For Students (leveled by grades):

		Grades:
Atheneum:		
Myller	How Big is a Foot	K - 3
Bowmar:		
Clure-Rumsey	Little Big Bigger	K - 3
Childrens Press:		
Carona	The True Book of Numbers	3 - 4
Columbia:		
Holden	Shapes, Space, & Symmetry	5 - 7
Crowell:		
Phillips	Right Angles (Paper Folding Geometry)	3 - 5
John Day:		
Alder	Directions and Angles	7 - 8
Alder	Sets	7 - 8
Knopf:		
Merriam-Galdone	A Gaggle of Geese	4 - 7
Preschool Press:		
Feltser	The Sesame Street Book of Numbers	K - 3
Van Norstrand Reinhold:		
Scripture	Puzzles and Teasers	6 - 7

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